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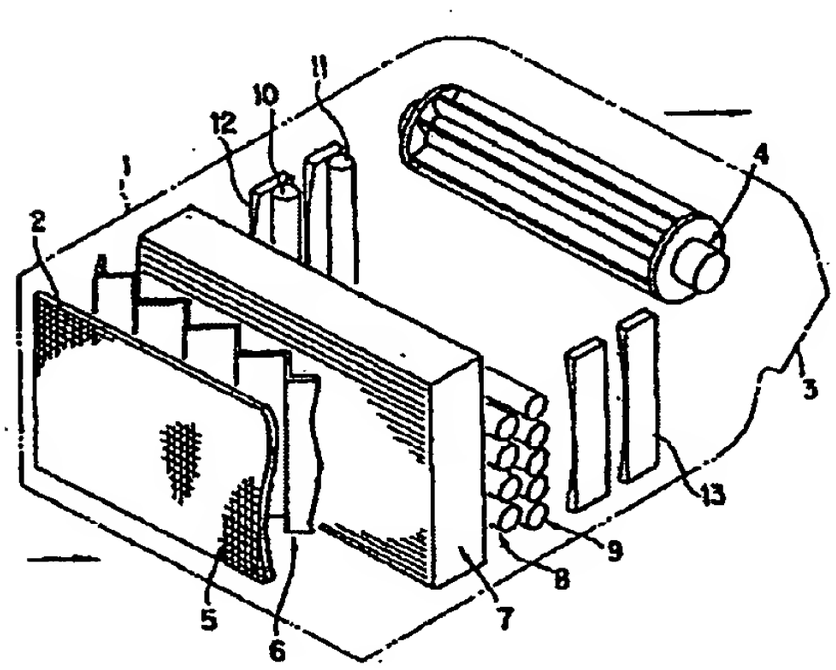
(54) [Title of the Invention] Sterilization, Deodorization and Purification Method of Air, and Apparatus of the Same

(57) [Abstract]

[Object] The present invention relates to a sterilization, deodorization and purification apparatus of air, and an object of the present invention is to obtain instantaneous deodorization effects by allowing singlet oxygen generated in aspirated and ozonized air to make a transition to ground state oxygen.

[Constitution] The present invention is a method in which singlet oxygen is generated by radiating one of ultraviolet ray and an ultraviolet laser beam which have a wavelength of 240 to 310 nm into air containing ozone which is generated by radiating one of ultraviolet ray and an ultraviolet laser beam which have a wavelength of 200 nm or less or by an electric discharge ozonizer. Then one of a visible light ray and a visible laser beam which have a wavelength of 600 to 650 nm, and one of a near infrared ray and a near infrared laser beam which have a wavelength of 1200 to 1300 nm are singly, simultaneously or sequentially radiated into this singlet oxygen, thus utilizing transition energy of the singlet oxygen to ground state oxygen by stimulated emission of electromagnetic wave.



[What is claimed is]

[Claim 1] A sterilization, deodorization and purification method of air in which singlet oxygen is generated by radiating one of ultraviolet ray and an ultraviolet laser beam which have a wavelength of 240 to 310 nm into air containing ozone which is generated by radiating one of ultraviolet ray and an ultraviolet laser beam which have a wavelength of 200 nm or less or by an electric discharge ozonizer. Then one of a visible light ray and a visible laser beam which have a wavelength of 600 to 650 nm, and one of a near infrared ray and a near infrared laser beam which have a wavelength of 1200 to 1300 nm are singly, simultaneously or sequentially radiated into this singlet oxygen, thus utilizing transition energy of the singlet oxygen to ground state oxygen by stimulated emission of electromagnetic wave.

[Claim 2] A sterilization, deodorization and purification apparatus of air comprising: ionization means such as air in an electrostatic dust collector for performing dust-collection and ionizing of air obtained by blowing or aspiration into a duct and a casing; ozone generating means for allowing the ionized air to generate ozone by radiating an ultraviolet ray and an ultraviolet laser beam, each of which has a wavelength of 200 nm or less, or by an electric discharge ozonizer; singlet oxygen generating means for generating singlet oxygen by radiating one of ultraviolet ray and ultraviolet laser beam which have a wavelength of 240 to 310 nm into the air in which ozone is generated by the ozone generating means; and transition to ground state oxygen means for radiating one of a visible light ray and a visible laser beam which have a wavelength of 600 to 650 nm, and one of a near infrared ray and a near infrared laser beam which have a wavelength of 1200 to 1300 nm singly, simultaneously or sequentially into the air in which the singlet oxygen is generated by the singlet oxygen generating means, thus allowing the singlet oxygen to make a transition to ground state oxygen by stimulated emission of electromagnetic wave.

[Detailed Descriptions of the Invention]

[0001]

[Industrial Application Field] The present invention relates to a sterilization, deodorization and purification method of air for protecting environment by allowing aspirated air to generate high concentration of ozone, and by allowing the high concentration of ozone to make a transition to singlet oxygen and allowing the singlet oxygen to make a transition to ground state oxygen.

[0002]

[Prior Art] For conventional sterilization of air, any one of a method of generating ozone by radiating ultraviolet ray having a wavelength of 185 nm and a method of performing sterilization by radiating ultraviolet ray by use of a bactericidal lamp of a wavelength of 254 nm has been used. Alternatively, a method in which these methods are combined has been used.

[0003]

[Subjects to be Solved by the Invention] However, the method of generating the ozone by the ultraviolet ray having the wavelength of 185 nm has a problem that the ozone must be discharged to the air as residual ozone before the ozone is fully decomposed, such ozone has large effect on human bodies, and handling of it is difficult. When the radiation of the ultraviolet ray by use of the bactericidal lamp is solely performed, there has been a problem that the ultraviolet ray having the wavelength of 254 nm is mainly used, excited singlet oxygen diffuses intact, and an effect that sterilization is instantaneously performed cannot be expected.

[0004] The present invention aims at solving the foregoing problems, and an object of the present invention is to provide a sterilization, deodorization and purification apparatus of air in which singlet oxygen generated in aspirated and ozonized air is immediately allowed to make a transition to ground state oxygen, and instantaneous sterilization effect is obtained.

[0005]

[Means for Solving the Subjects] The sterilization, deodorization and purification method of air according to the present invention

is one in which singlet oxygen is generated by radiating one of ultraviolet ray and an ultraviolet laser beam which have a wavelength of 240 to 310 nm into air containing ozone which is generated by radiating one of ultraviolet ray and an ultraviolet laser beam which have a wavelength of 200 nm or less or by an electric discharge ozonizer, and then one of a visible light ray and a visible laser beam which have a wavelength of 600 to 650 nm, and one of a near infrared ray and a near infrared laser beam which have a wavelength of 1200 to 1300 nm are singly, simultaneously or sequentially radiated into this singlet oxygen, thus utilizing transition energy of the singlet oxygen to ground state oxygen by stimulated emission of electromagnetic wave.

[0006] The sterilization, deodorization and purification apparatus of air according to the present invention comprises: ionization means such as air in an electrostatic dust collector for performing dust-collection and ionizing of air obtained by blowing or aspiration into a duct and a casing; ozone generating means for allowing the ionized air to generate ozone by radiating an ultraviolet ray and an ultraviolet laser beam, each of which has a wavelength of 200 nm or less, or by an electric discharge ozonizer; singlet oxygen generating means for generating singlet oxygen by radiating one of ultraviolet ray and ultraviolet laser beam, which have a wavelength of 240 to 310 nm, into the air in which ozone is generated by the ozone generating means; and transmission to ground state oxygen means for radiating one of a visible light ray and a visible laser beam which have a wavelength of 600 to 650 nm, and one of a near infrared ray and a near infrared laser beam which have a wavelength of 1200 to 1300 nm singly, simultaneously or sequentially into the air in which the singlet oxygen is generated by the singlet oxygen generating means, thus allowing the singlet oxygen to make a transition to ground state oxygen by stimulated emission of electromagnetic wave.

[0007]

[Operation] In the sterilization, deodorization and purification apparatus of air according to the present invention, air aspirated

into a duct for an air conditioner by a sirocco fan passes through an ionizer, whereby fine dusts are electrostatically precipitated, and the air is made to be easily ozonized by ionization. Thereafter, by radiation of an ultraviolet ray or an ultraviolet laser beam having a wavelength of 200 nm or less, or by allowing the air to pass through an electric discharge ozonizer, which are provided in the duct, ozone is generated in the aspirated air.

[0008] By radiating an ultraviolet ray or an ultraviolet laser beam which have a wavelength of 240 to 310 nm into the ozone generated in the aspirated air, the foregoing ozone is in the state expressed by the following formula.

$$O_3 + h\nu \quad (240 \text{ nm to } 310 \text{ nm}) \quad \rightarrow \quad 2^1\Delta g + {}^1D$$

Specifically, singlet oxygen particle $2^1\Delta g$ and singlet oxygen atom ^1D are generated.

[0009] Then, the singlet oxygen particle excited by absorption of the ultraviolet ray is in the state expressed by the following formula when a visible light ray having a wavelength of 600 nm to 650 nm is subsequently radiated.

$$2^1\Delta g + h\nu \ (600 \text{ nm to } 650 \text{ nm}) \rightarrow \quad 2^3\Sigma g$$

Specifically, the singlet oxygen particle performs stimulated emission of photon and, at the same time, makes a transition to a ground oxygen state particle $2^3\Sigma g$.

[0010] Furthermore, when a near infrared ray having a wavelength of 1200 nm to 1300 nm is radiated into the singlet oxygen atom ^1D instead of the radiation of the foregoing visible light ray, the singlet oxygen atom is in the state expressed by the following formula.

$$^1D + h\nu \ (1200 \text{ nm to } 1300 \text{ nm}) \rightarrow \quad {}^3\Sigma g$$

Specifically, the singlet oxygen atom ^1D makes a transition to a ground oxygen state atom $^3\Sigma g$.

[0011] Also when the foregoing radiation of the visible light ray and the near infrared ray are sequentially or simultaneously performed, the singlet oxygen particle and the singlet oxygen atom are in the states expressed by the following formulae.

$$2^1\Delta g + h\nu \ (600 \text{ nm to } 650 \text{ nm}) \rightarrow \quad 2^3\Sigma g$$

$^{1}D + h\nu$ (1200 nm to 1300 nm) $\rightarrow$ $^{3}\Sigma g$

In any of the states, the singlet oxygen particle and the singlet oxygen atom make transitions to a ground state oxygen particle expressed by $2^{3}\Sigma g$ and a ground state oxygen atom expressed by $^{3}\Sigma g$.

[0012] When the transition to the ground state oxygen atom decomposed in the above described manner is made, the singlet oxygen is in an excited state having high decomposition energy of 22.5 Kcal/mol. Accordingly, the singlet oxygen performs strong bactericidal action, and sterilization, deodorization and purification for the aspirated air are carried out.

[0013]

[Embodiments] Next, an example of an embodiment of the present invention will be described with reference to the drawings below. In Fig. 1 and Fig. 2 showing this method and apparatus, a sirocco fan 4 is placed on a side of an air outlet port 3 opposite to an air intake port 2 in a duct 1, and air intake from the air intake port 2 is performed.

[0014] In the duct 1 on the side of this air intake port 2, a large mesh prefilter 5 for adsorbing comparatively large dusts in the air is placed, and the aspirated air from which dusts having a large particle size are removed by this prefilter 5 passes through an ionizer 6 placed next to the prefilter 5, whereby dusts having a small particle size are charged to be plus.

[0015] A dust collection plate 7 charged to be minus is provided next to this ionizer 6, and the dust particles having a small particle size charged to be plus are electrostatically adhered to the dust collection plate 7. The aspirated air is charged to be minus by the pass through this dust collection plate 7, and is in a state where it is easily ozonized.

[0016] An ultraviolet ray lamp 8 emitting ultraviolet ray having a wavelength of 185 nm is placed behind this dust collection plate 7, and a second ultraviolet ray lamp 9 emitting ultraviolet ray having a wavelength of 254 nm is placed behind the ultraviolet ray lamp 8. Part of the aspirated air made to be easily ozonized

by passing through the foregoing dust collection plate 7 is allowed to generate ozone by a radiation of ultraviolet ray from the ultraviolet ray lamp 8. Furthermore, the ozone contained in the aspirated air is allowed to generate singlet oxygen by ultraviolet ray having a wavelength of 254 nm which is radiated by the ultraviolet ray lamp 9.

[0017] A visible light ray lamp 10 emitting visible light ray having a wavelength of 633 nm is placed behind the foregoing ultraviolet ray lamp 9 in the duct 1, and sequentially a near infrared ray lamp 11 emitting near infrared ray having a wavelength of 1278 nm is placed. In a part of the duct 1 where the visible light ray lamp 10 and the near infrared ray lamp 11 are placed, mirrors 12 and 13 for reflecting the light beams are provided, and a visible light ray screen and a near infrared ray screen are formed by reflecting the light beams with the mirrors 12 and 13.

[0018] The aspirated air, in which from the ozone the singlet oxygen is generated, passes sequentially through light ray screens of the visible light ray and the near infrared ray. The singlet oxygen particle makes a transit to a ground state oxygen particle by a radiation of the visible light ray having a wavelength of 633 nm at the time the aspirated air passes through the light ray screen of the visible light ray, accompanied with stimulated emission of electromagnetic wave.

[0019] The aspirated air which has passed through the light ray screen of the visible light ray then passes through the light ray screen of the near infrared ray having a wavelength of 1278 nm. At this time a singlet oxygen atom in ozone which has not made a transition to ground state oxygen particle makes a transition to a ground state oxygen atom by a radiation of the near infrared ray of the wavelength of 1278 nm. At the time of the transitions to the ground state oxygen, energy generated by the singlet oxygen reaches as much as 22.5 Kcal/mol. Therefore, sterilization of bacteria contained in the aspirated air is performed by this energy, and by this sterilization coupled with the foregoing removal of the dusts, sterilization, deodorization and purification for the

aspirated air are performed.

[0020] A sterilization test of general bacteria floating in the room was conducted by the above described embodiment, and the conditions of the test are as follows.

Room temperature: 22 ℃

Floor space of the room: 60 m^2

Air quantity in treatment: 4.2 m^3/min

Ultraviolet ray: 184 nm, 40 W

Ultraviolet ray: 254 nm, 75 W

Halogen lamp: visible light ray 600 nm, near infrared lay 1300 nm, 500 W

Test method: RSC sampler method (output 40 l)

Culture condition: 35 ℃, 48 hours of cultivation

[Table 1]

Elapsed Time	Number of Floating Bacteria in 40 l
0	45
1	21
2	15
3	8
4	2
5	1>

[0021] In the above described embodiment, though the radiation of the visible light ray and the radiation of the near infrared ray are sequentially performed, performing only one of the radiations of them may be enough. In addition, if ventilation means is provided in the duct, the sirocco fan needs not to be provided.

[0022]

[Effects of the Invention] As described above, in the present invention, the singlet oxygen excited by the stimulated emission of

the electromagnetic wave sterilizes bacteria in the air aspirated in the duct, deodorizes odor generated from bacteria and the like, and purifies the air by decomposition energy at the time the singlet oxygen makes the transition to the ground state.

[0023] Accordingly, the sterilization, deodorization and purification apparatus shows no resistance against the passage of the air during the process of polluted air treatment, and can sterilize and deodorize a large quantity of air instantaneously. Since the sterilization, deodorization and purification apparatus allows the singlet oxygen generated during the decomposition process of the ozone, that is, reactive oxygen, to make the transition to ground state oxygen, the apparatus can purify the air while recycling the oxygen.

[0024] Since the ozone is allowed to make the transition to ground state oxygen and sent out from the inside of the duct, the problem that the ozone is discharged to the air as residual ozone before the ozone is fully decomposed, has adverse effect on human bodies, and handling of the ozone is difficult, does not occur unlike the conventional cases where the air is ozonized by a radiation of ultraviolet ray, the air is sterilized by ultraviolet ray from a bactericidal lamp, or both of the ozonization and the sterilization are performed.

[0025] In addition, in the case where the ultraviolet ray bactericidal lamp is solely used, the ultraviolet ray having the wavelength of 254 nm is mainly employed, and the excited singlet oxygen diffuses intact so that instantaneous sterilization effects cannot be expected. In the present invention, since the sterilization is performed by the transition energy from the singlet oxygen to the ground state oxygen, instantaneous sterilization effects can be expected.

[0026] Accordingly, if this sterilization, deodorization and purification apparatus of air is used as ventilation means, as a matter of course hospital-acquired infection (MRSA) that is today's problem can be prevented. Sterility and deodorization of air in a living space of a building and means of transportation cab

be achieved. Furthermore the sterilization, deodorization and purification apparatus of air is applied to a place such as a food processing place, a kitchen, and a medical institution, where sterile space is required, and exhibits its effects.

[Brief Description of the Drawings]

[Figure 1] Fig. 1 is a perspective view of an embodiment of the present invention.

[Figure 2] Fig. 2 is a section view of the embodiment of the present invention.

[Explanations of Reference Numeral]

1.....duct, 3.....sirocco fan, 6.....ionizer, 7.....dust collection plate, 8.....ultraviolet ray lamp having a wavelength of 185 nm, 9.....second ultraviolet ray lamp having a wavelength of 254 nm, 10.....visible light ray lamp having a wavelength of 633 nm, 11.....near infrared ray lamp having a wavelength of 1278 nm, 12.....mirror, 13.....mirror.

Fig.1

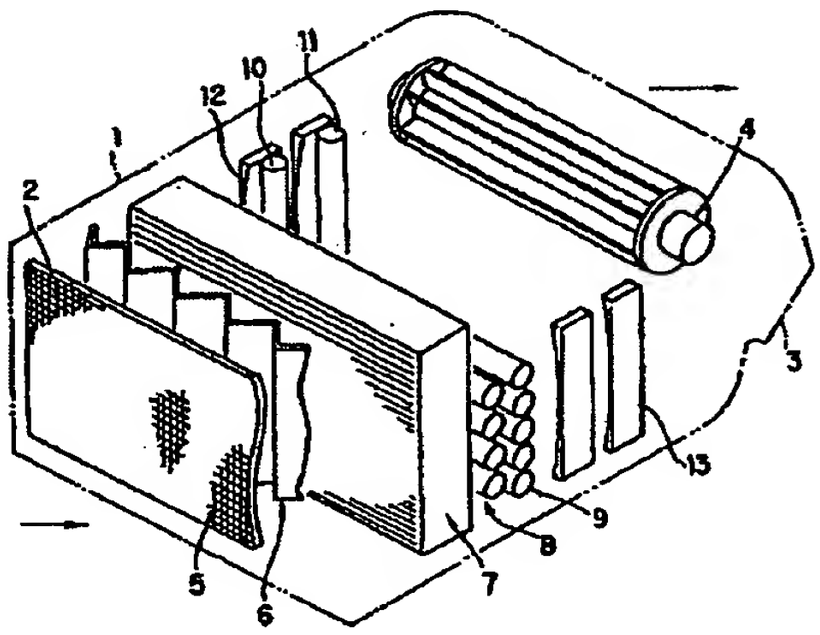


Fig.2

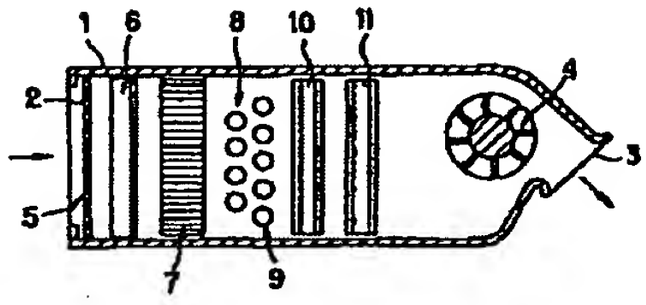


Fig.1

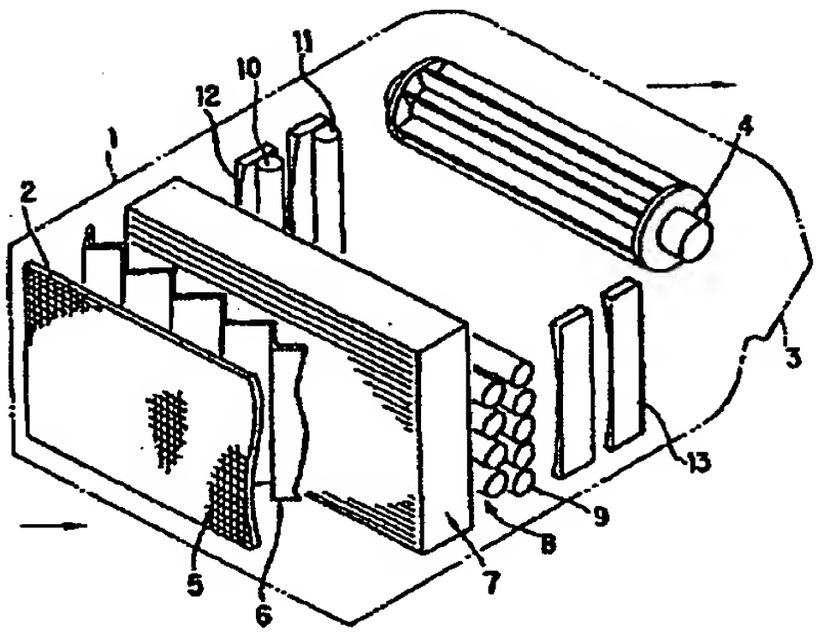


Fig.2